**Surface Response Model Characterizing and Predicting Selenium Nanoparticle Coatings on Medical Devices**

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**Statement of Purpose:** Selenium nanoparticles (SeNP) have been demonstrated to have significant antibacterial effects[1], as well as beneficial effects on healthy mammalian cells[2]. While the size and concentration of particles (both in solution as well as a substrate coating) have been controlled by changes in reactant molarities, the temporal parameters of the synthesis reaction has been left largely uncharacterized. Here, we developed and implemented a model for SeNP coatings on poly(l-lactic acid) (PLLA) according to a set of parameters. The key responses to the parameter changes include nanoparticle (NP) size, coverage and resulting surface energy. With the data collected, a cubic response surface model was developed using a central composite design (CCD), with which the resulting SeNP coating properties can be predicted. Eventually, this model will be extended to predict the interaction of the SeNP with bacteria and mammalian cells for numerous tissue engineering applications.

**Methods:** SeNP can be synthesized as either free NPs in solution or on a surface. For the purposes of this research, PLLA discs served as the binding surface for the particles. SeNP were synthesized via the reaction of glutathione (GSH) with sodium selenite ($Na_2SeO_3$) at a 4:1 molar ratio, respectively. After a time period, $T_1$, the particles were precipitated out of solution by the addition of sodium hydroxide. The reaction and precipitation was then halted after a second time interval, $T_2$, by the addition of water and rinsing of the samples.

In order to create an accurate response curve, forty-two separate reactions were performed. Each run had slight alterations to the input parameters to efficiently collect the data necessary for a meaningful model. Varied characteristics included the time (both $T_1$ and $T_2$), the volume of the reactant ion solution, and the total substrate area present (i.e., the number of samples coated per reaction). The samples were analyzed with SEM imaging for size and coverage and goniometry for resulting surface energy.

**Results and Discussion:** It was expected that an increase in reacting coating time would correlate with an increase of nanoparticles bound to the PLLA substrate according to preliminary results and earlier observations. Figure 1 shows the SEM micrographs of samples with different coating time increments. Figure 1A has a $T_1$ and $T_2$ of 16.15 seconds each while 1B has increments of 60.00 and 32.50 seconds. The SEM images showed that an increase in both time increments led to an increased precipitation of nanoparticles.

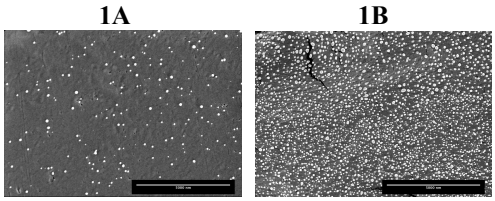


**Figure 1A** is a SEM image of a run with both $T_1$ and $T_2$ equal to 16.15 seconds. **Figure 1B** is a SEM image of a trial with time increments equal to 60.00 and 32.50 seconds ($T_1$, $T_2$).

An increase in one of the time increments resulted in larger nanoparticle coverage. Figure 2A represents the development times of 16.15 seconds for each time increment while Figure 2B demonstrates time increments of 16.15 and 48.85 seconds for $T_1$ and $T_2$, respectively. While there was an increase in coverage when altering one of the time increments, the increase was smaller than when both of the increments were varied.

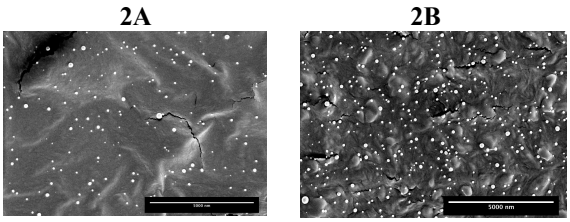


**Figure 2A** is a SEM image of a run with $T_1$ and $T_2$ equal to 16.15 seconds. **Figure 2B** is a SEM image of a run with time increments of 16.15 and 48.85 seconds ($T_1$, $T_2$).

**Conclusions:** As expected, longer coating times led to greater SeNP surface coverage, but only to a certain point. At longer time points, the coverage of the substrate reached a limit, suggesting a saturation point of the substrate for "binding sites" for the SeNP. With a larger number of discs present, the saturation point increased since there was more surface area available for binding. Through the application of this one-of-a-kind SeNP response model, experimental procedures will be designed with more focused specifications, allowing for optimization of the SeNP coating process for both medical research and industrial applications.

**References:**

1. Tran A. Phong et al. "Titanium surfaces with adherent selenium nanoclusters as a novel anticancer orthopedic material." *J Biomedical Materials Research* (2009): 1417-1428
2. Legrain Yona, Touat-Hamici Zahia, Chavatte Laurent, "Selenoproteins and replicative senescence."*J Biol Chem* (2014) 289: 14750-14761.